INSTRUMENT CENTER
INSTRUCTION BOOK
MODEL 98A
DIFFERENTIAL DC
VOLTMETER-AMPLIFIER

INSTRUMENT CENTER

Boonton ELECTRONICS Corporation
MORRIS PLAINS, NEW JERSEY

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INSTRUCTION BOOK

MODEL 98A

DIFFERENTIAL DC

VOLTMETER-AMPLIFIER

Boonton *ELECTRONICS* Corporation

738 SPEEDWELL AVENUE, MORRIS PLAINS. NEW JERSEY, U. S, A.

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I. GENERAL DESCRIPTION

1-1. DESCRIPTION

1-2. The Model 98-A Differential DC Voltmeter Amplifier is a three terminal voltmeter amplifier designed for DC measurements over the range of 10 microvolts to 1000 volts.

1-3. The three terminal feature permits the instrument to be used for voltage measurements above ground, or to be operated as a differential voltmeter or amplifier to measure small difference voltages between relatively large DC voltages. Also the instrument is ideal for comparing or adjusting critical voltages against reference voltages such as a standard cell, or for measuring the voltage variations of highly regulated DC power supplies.

1-4. The 98-A may also be used as a conventional two terminal DC voltmeter. This requires that the negative input be grounded. Then all measurements made between the plus input and ground will indicate amplitude and polarity directly on the front panel meter.

1-5. A six-inch, direct-reading, zero-center, mirrored meter scale indicates voltage polarity, and eliminates the necessity of reversing meter test leads, or of using a polarity reversing switch when measuring voltages. This is achieved through the use of a synchronous output rectifier consisting of a transistor switching circuit driven in phase with the input chopper. The arrangement provides the proper polarity indication on the panel meter. It also completely isolates output from input, thus eliminating the undesirable feedback often encountered when both input and output choppers are enclosed in the same envelope.

1-6. The high input impedance of the Model 98-A Differential DC Voltmeter-Amplifier is achieved by means of special break-before-make, low noise chopper circuitry, plus a high input resistance voltage divider. The chopper output is amplified by a stable, high-gain feedback a-c amplifier, then synchronously rectified to provide voltage indications of a magnitude and polarity proportional to those of the test voltages. Thus the exceptionally high degree of stability of the Model 98-A is attained without the use of d-c amplification stages.

1-7. D-c output binding posts mounted on the front panel permit interconnection and operation of indicating or control devices such as relays or recording milliammeters. The output at the binding posts may be used simultaneously with the meter without interaction.

1-8. Voltages as high as 1500 volts may be accidently applied to the Model 98-A input without causing damage to the equipment and with rapid recovery. A protective circuit at the attenuator output guards the instrument from accidental overload.

1-9. As a d-c amplifier the Model 98-A has a maximum gain of 70 DB and is capable of providing $\pm$ 0.5 ma into a 1500-ohm load. An output bias control in the instrument allows the adjustment of output to any current between 0 and 0.6 ma, with zero d-c input condition.

1-10. TECHNICAL CHARACTERISTICS

Measurement Range	10 uv to 1000 volts
Full Scale ranges	.3, 1.0, 3.0, 10, 30, 100, 300mv 1.0, 3.0, 10, 30, 100, 300,1000V.
Accuracy	3.0 percent of full scale on 1.0 mv range and up: 4.0 percent on 0.3 mv range

Differential Input Resistance	Neg term to gnd.	Neg to plus term	Plus term. to gnd.
.3 mv range	27 megs	9 megs	27 megs
1.0 mv range	27 megs	9 megs	27 megs
3 mv range	30 megs	27 megs	30 megs
10 mv range	40 megs	75 megs	40 megs
30 mv range	49 megs	98 megs	49 megs
100 mv range to 1000V range	50 megs	100 megs	50 megs

Two Terminal Input Resistance (negative (-) terminal grounded)	
.3 mv range	8 meg.
1.0 mv range	8 meg.
3.0 mv range	20 meg.
10.0 mv range	40 meg.
30.0 mv to 1000 V range	50 meg.

DC Common Mode Rejection	approximately 80DB
60 cycle rejection	greater than 60 DB
Maximum Amplifier gain	approximately 70 DB
Output Impedance	1200 ohms (approx)
Output capability (Min)	±0.5 ma across 1500 ohms, or ±1.5V no load.
Zero drift	± 2% of F.S.approx.(after warm up)
Power requirements	30 watt
Weight	11 lbs.(shipping weight 16 lbs.)

1-11. LEADING PARTICULARS

1-12. Table 1-1 lests the equipment supplied. Table 1-2 lists the tube complement of DC Voltmeter-Amplifier, Model 98-A. Tables 1-3 and 1-4 list, respectively, the fuse complement and the chopper complement of the voltmeter-amplifier.

TABLE 1-1, EQUIPMENT SUPPLIED

No. Per Equipment	Name of Unit	Overall Dimensions (Max) H	W	D
1	Model 98-A Differential DC Voltmeter-Amplifier	12-1/4"	7-1/8"	9-3/8"
2	Input cable assembly Red or black alligator clip may be removed to allow use of phone tip	4 ft. approximately		
1	Instruction book			

TABLE 1-2, ELECTRON TUBE COMPLEMENT

No. per Equipment	Tube Designation	Type	Function
1	V1	12AX7	Amplifier
1	V2	6 AU6	Amplifier
1	V3	12AT7	Amplifier-Cathode Follower
1	V4	6X4	Rectifier
1	V5	0A2	Voltage Regulator

TABLE 1-3, FUSE COMPLEMENT

Fuse Rating	AGC 1.0 ampere

TABLE 1-4, CHOPPER COMPLEMENT

Mechanical Chopper Rating	0 to 1-1/2 volts, dc, 1.0 ma
Transistor Chopper Type	2N34

II. OPERATING PROCEDURES

2-1. GENERAL

2-2. This section describes in detail the operating procedure for the Model 98-A Differential Voltmeter-Amplifier. All information required for safe and proper operation of the instrument is included. BE SURE TO READ THIS SECTION BEFORE PLACING THE INSTRUMENT INTO OPERATION.

2-3. INITIAL TURN-ON PROCEDURE AND TESTS.

2-4. TESTS. To perform the initial tests proceed as follows:

a. After unpacking the unit and before plugging it into an a-c outlet for the first time, turn the instrument back and forth several times to make sure the tubes have not fallen from their sockets due to rough handling.

b. Observe the meter pointer to see that it moves freely and rests at zero when the instrument is steady.

c. If the pointer rests to the right or left of zero, set it at zero with the zero set screw.

CAUTION

Before plugging the instrument into the convenience outlet, make sure the power line voltage and frequency is within ± 10% of that indicated by the power rating plate.

2-5. TURN-ON PROCEDURE. To perform the initial turn-on procedure proceed as follows:

a. Plug the instrument into the power source.

b. Set ON toggle switch to ON(up), and allow a warm-up period of approximately one minute.

c. Connect the input cables to the instrument, (cable assembly with red probe connect to input marked "+") and short together all three alligator clips.

d. Set the range switch/attenuator to the desired measuring range, and adjust the ZERO control to set the meter pointer at zero center.

2-6. OPERATION

2-7. DIFFERENTIAL MEASUREMENTS. There are two methods of using the 98-A for measuring the difference between two voltages. One is to allow the ground of the instrument to float and apply the test between minus (-) and plus (+) input. For example: the difference between two 100 volt power supplies are to be measured, connect the two negative terminals of the supplies together, and apply one of the + 100 volts to the minus input (-) and the other + 100 volts to the plus (+) input of the 98-A.

The range switch is switched down to a range where an indication is observed on the front panel meter. This will indicate the true difference voltage. This method is accurate because only the difference between the two voltages is applied to the 98-A. When using the most sensitive ranges, however, hum and/or noise may be encountered which will introduce error unless the test is well shielded.

The second method is to apply the test directly across each input to ground. This method requires that the input attenuators be perfectly balanced. This is accomplished by connecting both inputs together to a common voltage and adjusting the front panel meter to zero with the ZERO adjust control.

When reconnected to the voltages to be measured, the 98-A will then read the true difference between the two applied voltages.

When using the 98-A to compare or to adjust two voltages, always connect the standard or reference voltage to the negative input and the test voltage to the positive input. This will polarize the instrument with respect to the test voltage; that is, if the test voltage is larger than the standard voltage the 98-A will indicate positive, and vice versa.

a. The dual input attenuators of the 98-A are balanced at the factory to be within the range of the ZERO adjust (See Table 4-2). This will allow differential measurements to be made to approximately 80 DB. Table (2-1) lists maximum allowable voltage for each range. Do not exceed these voltages when using the instrument for differential work or the instrument will not indicate properly.

TABLE 2-1

MAXIMUM INPUT VOLTAGE TO GROUND FOR DIFFERENTIAL MEASUREMENTS

Range	Max. voltage
.3 millivolt	30 volts
1.0 millivolt	30 volts
3.0 millivolt	100 volts
10.0 millivolt	300 volts
30.0 millivolt	1000 volts
100 millivolts and above	1500 volts max.

2-8. DC VOLTAGE MEASUREMENTS: the 98-A may be used as a conventional two terminal DC voltmeter or amplifier simply by shorting the minus (-) input to ground and applying the test

between ground and plus (+) terminal. The input impedance for each range will be as listed in Technical Characteristics under Two Terminal Input Impedance. The voltage accuracy listed under Technical Characteristics will apply.

NOTE

Whenever measuring ranges are changed, the zeroing procedure outlined in paragraphs 2-5-c and 2-5-d should be followed. In general, however, the zero will not require resetting when switching to any range between 30 millivolts and 1000 volts full scale.

2-9. OPERATING PRECAUTIONS

2-10. The Model 98-A Differential DC Voltmeter-Amplifier is provided with special overload circuits on each input which permits accidental application of as much as 1500 volts to the input even on the most sensitive range without damage to the instrument. However, DO NOT EXCEED 1500 VOLTS PEAK INPUT UNDER ANY CIRCUMSTANCES.

NOTE

When the instrument has not been turned on for several hours during very humid weather, it may be desirable to allow a one-hour warm-up (to drive off accumulated moisture) before making measurements.

2-11. UNWANTED METER INDICATIONS

2-12. In an instrument capable of indicating an input signal as small as a few microvolts, several sources of unwanted meter indications are of importance. One of the most troublesome of

these is hum pickup. A built-in hum rejection filter in the instrument reduces these hum pickup effects by more than 60 DB.

2-13. Other effects that may produce unwanted signal voltages are as follows:

a. Thermocouple junctions (heat effects).

b. Galvanic action (battery effect).

c. Photosensitivity (particularly of semiconductor devices).

d. Amplifier noise (due to noisy components, microphonic tubes, and tube noise).

2-14. In using the differential voltmeter-amplifier observe the normal precautions that apply when using any type of voltmeter. For example, when measuring unknown values of voltage, always set the range switch/attenuator to the highest range, then decrease the setting to the proper range.

2-15. USE AS AN AMPLIFIER

2-16. If the instrument is used as an amplifier, the signal is taken from the output terminals on the front panel. The front panel range switch is used to vary the gain of the amplifier. The amplifier output is proportional to the front panel meter indication and should not be operated beyond full scale. An output bias is provided in the instrument which applies a voltage to the negative output post. This voltage may be adjusted by means of the OUTPUT BIAS ADJ located on the right side of the instrument. It provides bias to external indicators so that they may be operated either from zero or at a midscale point in which case a negative input voltage will indicate left and positive to the right.

III GENERAL CIRCUIT DESCRIPTION

3-1. The circuit consists of a dual input attenuator; a dual filter circuit to reduce the effect of 60 cycle hum pickup; an overload protective circuit on each input to limit the voltage applied to the chopper; a chopper to convert the difference voltage between the two inputs to 60 cps ac; four feedback amplifier stages; a transistorized chopper circuit that converts the amplified ac to dc; a zero center d-c voltmeter calibrated in volts and millivolts; a cathode follower output circuit; and a d-c power supply source.

IV MAINTENANCE

4-1. The 98-A should give long trouble free service in the field, but if trouble should arise, the following will assist the operator in locating and repairing the problem.

4-2. The principal parts in the instrument subject to possible failure are the electrolytic capacitors, tubes, choppers, and the selenium rectifier.

4-3. Because of the very low signal level and high stage gain, components in the V1 (12AX7) circuit are more likely to develop unsatisfactory noise conditions or to exhibit instability, than those components used where signal levels are higher.

4-4. REMOVAL. To remove the panel assembly proceed as follows:

a. Remove the four screws located at the front portion of the Model 98-A case assembly sides.

b. Remove the two screws at the back of the case assembly bottom.

C. Pull out the power connector plug from the power supply socket, and remove the voltmeter and amplifier assembly.

4-5. To remove the power supply assembly, remove the four screws at the rear of the case assembly sides, and pull out the power supply assembly. Use care in pulling the power cord through the hole in the case assembly to prevent breaking the junction of the cord and plug.

4-6. Figure 4-1 lists voltages and resistances to aid in trouble shooting.

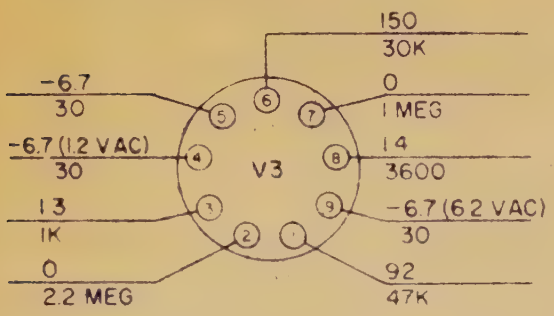
4-7 BALANCE TEST: (Warm up in cabinet at least one hour before making readings). To check the balance of the two inputs and the attenuator proceed as follows:

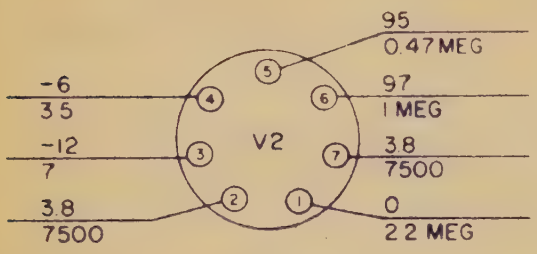
a. Connect the red and black test lead together and apply input voltages between the test leads and ground, as shown in Table 4-2. On the corresponding ranges the error reading should be no greater than 40% of full scale when the zero control is set at its mid point.

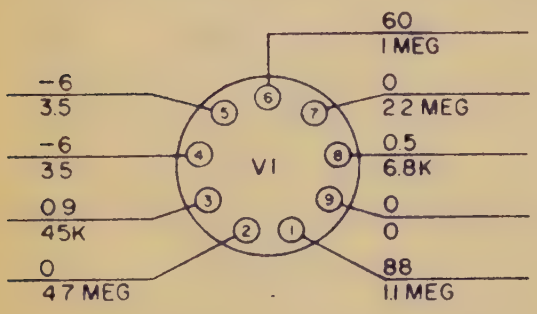
TABLE 4-2

Range	Input Voltage
.3 millivolt	IV
1.0 millivolt	IV
3.0 millivolt	3V
10 millivolt	10V
30 millivolt	30V
100 millivolt	100V
300 millivolt	300V
1.0 volt to 1000V	1000V

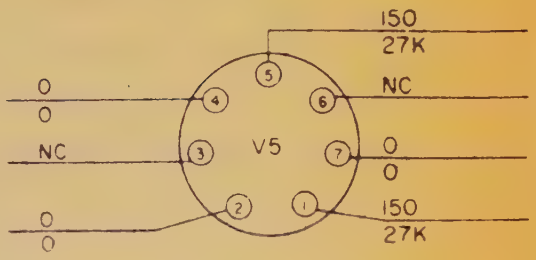
VOLTMETER AMPLIFIER ASSEMBLY

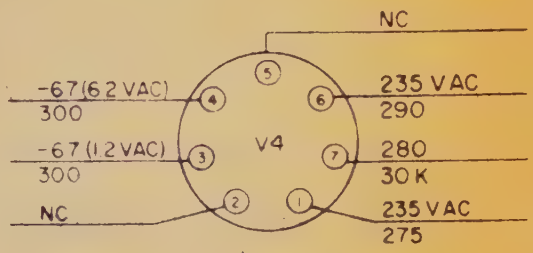


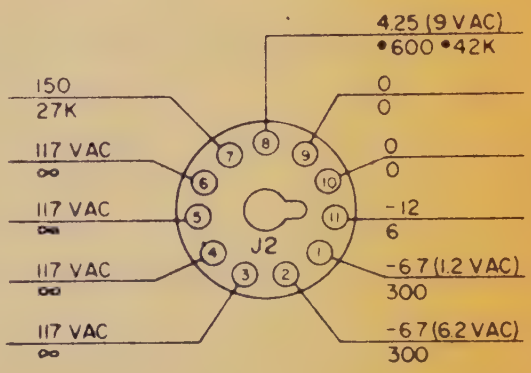




POWER SUPPLY ASSEMBLY







•-MEASURED WITH 20,000 OHM/VOLT METER, LEADS REVERSED AFTER FIRST MEASUREMENT. MEASUREMENTS ARE APPROXIMATE

NOTES

1. TUBE SOCKET LOCATIONS SHOWN ARE BOTTOM VIEWS.
2. VOLTAGES ARE TOP OF LINE, RESISTANCES BOTTOM.
3. VOLTAGES ARE DC UNLESS OTHERWISE NOTED.
4. RESISTANCES ARE IN OHMS UNLESS OTHERWISE NOTED.
5. D-C VOLTAGES AND RESISTANCES ARE MEASURED BY 20,000 OHM/VOLT METER
6. A-C VOLTAGES ARE MEASURED WITH VTVM.
7. ALL MEASUREMENTS MADE FROM PIN TO CHASSIS, CHASSIS INTERCONNECTED
8. ZERO CONTROL AND RANGE-FULL SCALE SWITCH FULLY CLOCKWISE.

Figure 4-1 Voltage and Resistance Measurements

4-8 ATTENUATOR BALANCE PROCEDURE

a. Warm up in cabinet for at least one hour before proceeding with balance adjustments.

b. Remove the holding screws as described in para. 4-4 a & b. Leave the voltmeter inside the cabinet except when actually making each adjustment.

c. Connect the plus (+) and minus (-) clips to the ground clip (all shorted) and adjust meter to zero (mid scale) on the 3.0 millivolt range.

d. Connect the plus (+) and minus (-) clips together and apply approximately + 3.0 volts DC between them and the ground clip.

e. With an insulated screwdriver adjust the "3" (located on top of the switch/attenuator shield can) for a meter reading of zero (mid-scale).

f. Apply 10 volts on the 10.0 millivolt range and adjust "4" for zero.

g. Apply 30 volts on the 30.0 millivolt range and adjust "5" for zero.

h. Apply 100 volts on the 100.0 millivolt range and adjust "6" for zero.

i. Apply 300 volts on the 300 millivolt range and adjust "7" for zero.

j. Apply 1000 volts on the 1.0 volt range and adjust "8" for zero.

k. All higher voltage ranges should be balanced within 40% of full scale when 1000 volts is applied.

4-9 CALIBRATION PROCEDURE

4-10 Calibration of the Model 98-A can be performed in a few simple steps, as described below.

4-11. The calibrating source can be any voltage source whose accuracy is known, preferably between 0.1 percent and 1.0 percent. For field calibration a fresh flashlight battery (1.56-volt output) and a voltage divider composed of 1.0 percent resistors with a total resistance considerably less than the input impedance of the 98-A, will be of sufficient accuracy. For laboratory calibration it is preferred that a known voltage source with an accuracy of 0.1 percent or better be employed.

a. Turn on the 98-A and allow to stabilize for approximately 30 minutes.

b. Set RANGE-FULL SCALE switch on Model 98-A to .3 MILLIVOLTS position.

c. With zero output from voltage source, and with input cable clips shorted together to ground clip, zero the Model 98-A using the ZERO control.

d. Adjust voltage source to provide 0.3 millivolt between the positive and negative input with the ground clip connected to the negative input.

e. Adjust the "1" control on the side of the Model 98-A so that the pointer on the meter reads exactly full scale.

f. Recheck ZERO as in step c; reset if necessary.

g. Recheck full scale reading with 0.3 mv input. If necessary, repeat step e.

h. Reverse the leads from the voltage source and read the indication on the Model 98-A. If the reading is nominal, no further adjustment of the "1" control is required. However, if the indication of the two polarities differ, readjust the 1 control so that the average of the two readings is nominal (i.e. 0.3 mv in this instance).

i. Repeat steps b through h for the 1.0 millivolt range of the Model 98-A, using a 1.0 mv source and adjusting the "2" control. This completes the calibration.

TABLE OF REPLACEABLE PARTS

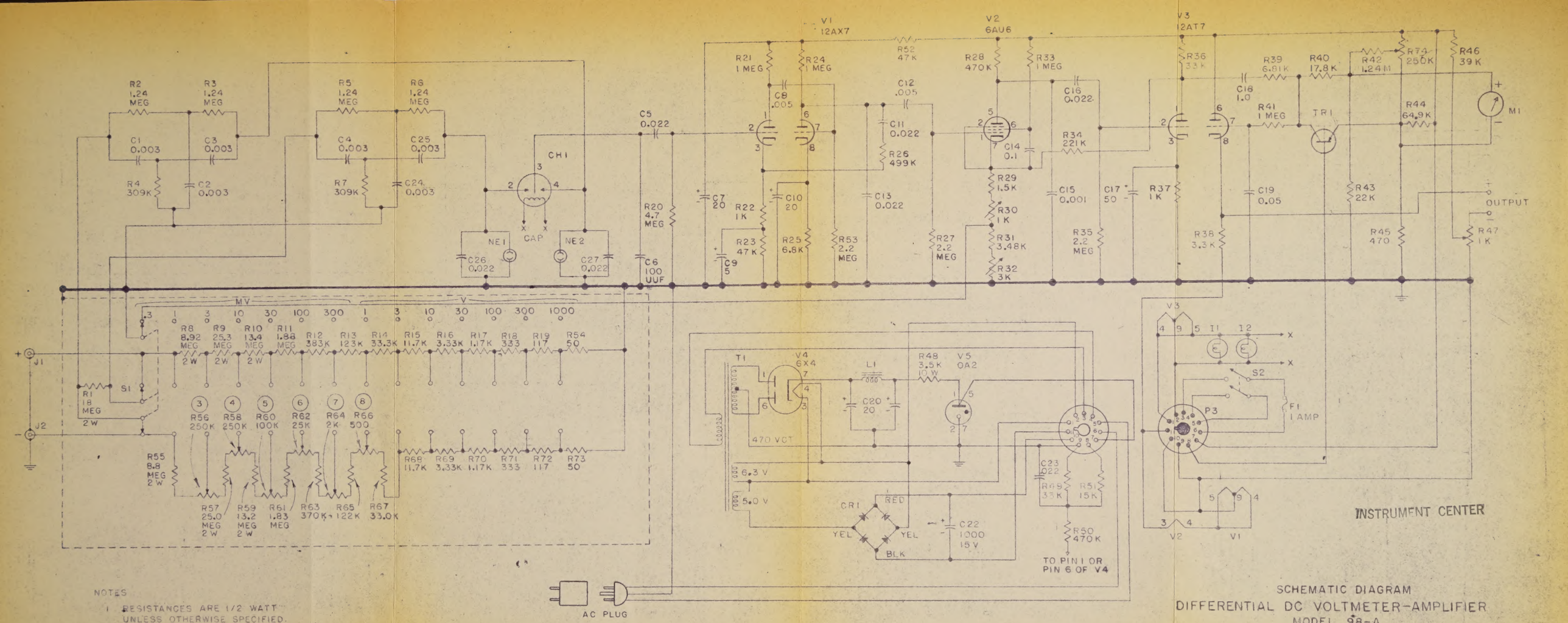
Reference Symbol	Description
C1, C2, C3, C4, C24, C25	CAPACITOR, silver mica, 0.003μf ±1% (MIL type CM30C or D)
C5, C8, C11, C12, C13, C16, C26, C27	CAPACITOR, plastic, tubular, 0.022μf ±20%, 200vdcw (Good-All 620M22302)
C6	CAPACITOR, silver mica, 100μμf ±10% (MIL type CM20C101K)
C7, C10, C17	CAPACITOR, electrolytic, 20μf X 475vdc, 50μf X 50vdc, 20μf X 25vdc. (Mallory FP 379.1)
C9	CAPACITOR, electrolytic, tubular, 5μf, 6V (C-D BBR-5-6)
C14	CAPACITOR, paper, tubular, 0.1μf ±20% 200vdcw (Aerovox P-82Z)
C15	CAPACITOR, mica, .001 μf ±20% (MIL type CM20B102M)
C18	CAPACITOR, paper, 1.0μf ±20%, 200vdcw (Aerovox P82Z)
C19, C23	CAPACITOR, paper, tubular, .05μf ±10%, 200vdcw (Aerovox P82Z)
C20, C21	CAPACITOR, electrolytic, 20μf X 20μf X 450vdcw. (Mallory FP-234)
C22	CAPACITOR, electrolytic, 1000μf X 15vdcw (Mallory WP-039)
CH1	CHOPPER, SPST, break-before-make (Stevens-Arnold A-12)
F1	FUSE, 1 amp. (Buss AGC-1)
I1, I2	LAMP, 6V, bayonet, p/o meter M1 (GE no. 51)
J1, J2	RECEPTACLE, Input (Amphenol 80-C)
J3	SOCKET, 11 pin (Amphenol 77-MIP-11)
L1	CHOKE, 7 hy at 50 ma (Stancor C1707)
M1	METER, 100-0-100 microammeter, special calibration. (Phaostron)

Reference Symbol	Description
NE1, NE2	LAMP, neon, 1/25 watt (GE NE-2)
P3	PLUG, 11 pin, (Amphenol 86-PM-11-11)
R1	RESISTOR, carbon deposit, 16.5MΩ ±1%, 2W (Texas Instrument CD2R)
R2, R3, R5, R6	RESISTOR, carbon deposit, 1.24MΩ ±1%,1/2W (Texas Instrument CD 1/2SR)
R4, R7	RESISTOR, carbon deposit, 309KΩ ±1%, 1/2W (Texas Instrument CD 1/2SR)
R8	RESISTOR, carbon deposit, 8.92MΩ ±1/2%, 2W. (Texas Instrument CD 2R)
R9	RESISTOR, carbon deposit, 25.3MΩ ±1/2%,2W (Texas Instrument CD 2R)
R10	RESISTOR, carbon deposit, 13.4MΩ,±1/2%,2W (Texas Instrument CD2R)
R11	RESISTOR, carbon deposit, 1.88MΩ ±1/2%,1/2W (Texas Instrument CD 1/2SR)
R12	RESISTOR, carbon deposit, 383KΩ ±1/2%,1/2W (Texas Instrument CD 1/2SR)
R13	RESISTOR, carbon deposit, 123KΩ 1/2%,1/2W (Texas Instrument CD 1/2SR)
R14	RESISTOR, carbon deposit, 33.3KΩ 1/2%,1/2W (Texas Instrument CD 1/2SR)
R15, R68	RESISTOR, carbon deposit, 11.7KΩ 1/2%,1/2W (Texas Instrument CD 1/2SR)
R16, R67	RESISTOR, carbon deposit, 3.33KΩ 1/2%,1/2W (Texas Instrument CD 1/2SR)
R17, R70	RESISTOR, carbon deposit, 1.17KΩ 1/2%,1/2W (Texas Instrument CD 1/2SR)
R18, R71	RESISTOR, carbon deposit, 333Ω 1/2%, 1/2W (Texas Instrument CD 1/2SR)
R19, R72	RESISTOR, carbon deposit, 117Ω 1/2%,1/2W (Texas Instrument CD 1/2SR)
R20	RESISTOR, composition, 4.7MΩ ± 5%,1/2W (Allen-Bradley EB)
R21, R24, R33, R41	RESISTOR, composition, 1.0MΩ ±5%, 1/2W (Allen-Bradley EB)

Reference Symbol	Description
R22, R37	RESISTOR, composition, 1000Ω ±5%, 1/2W (Allen-Bradley EB)
R23, R52	RESISTOR, composition, 47KΩ ±5%, 1/2W (Allen-Bradley EB)
R25	RESISTOR, composition, 6800Ω ±1%, 1/2W (Allen-Bradley EB)
R26	RESISTOR, carbon deposit, 499KΩ ±1%, 1/2W (Texas Instrument CD 1/2SR)
R27, R35, R53	RESISTOR, composition, 2.2MΩ ±5%, 1/2W (Allen-Bradley EB)
R28, R50	RESISTOR, composition, 470KΩ ±10%, 1/2W (Allen-Bradley EB)
R29	RESISTOR, carbon deposit, 1.5KΩ ±1%, 1/2W (Texas Instrument CD 1/2SR)
R30	RESISTOR, variable, 1KΩ ±2%, linear (IRC 34-1610-7395)
R31	RESISTOR, carbon deposit, 3.48KΩ ±1%, 1/2W (Texas Instrument CD 1/2SR)
R32	RESISTOR, variable, 3KΩ ±20% linear (IRC RQ11-112)
R34	RESISTOR, carbon deposit, 221KΩ ±1%, 1/2W (Texas Instrument CD 1/2SR)
R36, R49	RESISTOR, composition, 33KΩ ±5%, 1/2W (Allen-Bradley EB)
R38	RESISTOR, composition, 3.3K; ±5%, 1/2W (Allen-Bradley EB)
R39	RESISTOR, carbon deposit, 10KΩ ±1%, 1/2W (Texas Instrument CD 1/2SR)
R40	RESISTOR, carbon deposit, 17.8K ±1%, 1/2W (Texas Instrument CD 1/2SR)
R42	RESISTOR, Carbon Deposit, 1.24MΩ ±.1%, 1/2W (Texas Instrument CD 1/2 SR)
R43	RESISTOR, composition, 22KΩ ±10%, 1/2W (Allen-Bradley EB)
R44	RESISTOR, Carbon Deposit, 64.9KΩ, ±1%, 1/2W (Texas Instrument CD 1/2 SR)

Reference Symbol	Description
R45	RESISTOR, composition, 470Ω ± 5% (Allen-Bradley type EB)
R46	RESISTOR, composition, 39KΩ ±5%, 1W (Allen-Bradley GB)
R47	RESISTOR, variable, 1KΩ ±20%, slotted shaft (IRC PQ11-108)
R48	RESISTOR, wire wound, 3.5KΩ ±10%, 10W (Ohmite Brown Devil)
R51	RESISTOR, composition, 15KΩ ±5%, 1/2W (Allen-Bradley EB)
R54, R73	RESISTOR, carbon deposit, 50Ω ±1/2%, 1/2W (Texas Instrument CD 1/2SR)
R55	RESISTOR, carbon deposit, 8.8MΩ ±1/2%, 2W (Texas Instrument CD2R)
R56, R58	RESISTOR, variable, 250KΩ, slotted shaft (Centralab Model 6, modified)
R57	RESISTOR, carbon deposit, 25.0MΩ ±1/2%, 2W (Texas Instrument CD2R)
R59	RESISTOR, carbon deposit, 13.2MΩ ±1/2%, 2W (Texas Instrument CD2R)
R60	RESISTOR, variable, 100KΩ, slotted shaft (Centralab Model 6, modified)
R61	RESISTOR, carbon deposit, 1.83MΩ ±1/2%, 1/2W (Texas Instrument CD 1/2SR)
R62	RESISTOR, variable, 25KΩ, slotted shaft (Centralab Model 6, modified)
R63	RESISTOR, carbon deposit, 370KΩ, 1/2%, 1/2W (Texas Instrument CD1/2SR)
R64	RESISTOR, variable, 2KΩ, slotted shaft (Centralab Model 6, modified)
R65	RESISTOR, carbon deposit, 122KΩ 1/2%, 1/2W (Texas Instrument CD 1/2SR)
R66	RESISTOR, variable, 500Ω, slotted shaft (Centralab Model 6, modified)
R67	RESISTOR, carbon deposit, 33.0KΩ 1/2%, 1/2W (Texas Instrument CD 1/2SR)

Reference Symbol	Description
S1	SWITCH (Oak DLX Special 18 point)
S2	SWITCH, toggle. DPST (Carling 216-62)
T1	TRANSFORMER, power (Stancor PC8401)
TR1	TRANSISTOR, (Sylvania type 2N34)
V1	TUBE, electron 12AX7
V2	TUBE, electron 6AU6
V3	TUBE, electron, 12AT7
V4	TUBE, electron, 6X4
V5	TUBE, electron, 0A2
R74	RESISTOR, variable, 250KΩ (Allen-Bradley, Type J)



NOTES

1 RESISTANCES ARE 1/2 WATT UNLESS OTHERWISE SPECIFIED.

2 CAPACITANCES ARE IN MICROFARADS UNLESS OTHERWISE SPECIFIED

SCHEMATIC DIAGRAM
DIFFERENTIAL DC VOLTMETER-AMPLIFIER
MODEL 98-A

BOONTON ELECTRONICS CORP.
MORRIS PLAINS, N.J.

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